Space Weather Technical Forecast

Issued on Tuesday, 20 December 2022 at 13:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-class flares and G1/Minor Geomagnetic Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low, with occasional C-class flares, with the largest flares including a C8.1 flare at 19/1429UTC from AR3169 (Fsi/Beta) which has produced the majority of the observed activity, and a peak C8.2 at 20/0853 UTC from AR3170 (Cro/Beta). There are seven sunspots on the disc, AR3169 in the northwest consists of three mature, small but similarly sized leader spots connected to much smaller spots in its trailer region, with some spreading of spots observed. AR3171 Dsi/Beta-gamma to the west of this spot is a smaller region, primarily comprised of a small mature spot, but with a more complex collection of smaller opposite polarity spots to the west and east of the main spot. AR3170 is a much smaller and simple spot in the southwest. The largest region is AR3163 Eko/Beta in the southwest, which has seen its main leader grow, alongside the emergence of a small reverse polarity region near it, while its trailer remains much weaker. The other spots are generally smaller and simple. There are no Earth-directed CMEs, with the north-centre filament eruption around 19/2000 UTC having been assessed as reabsorbed. Further slight eruptions have been off the Earth-Sun line. There is also large filament across the southern centre disc that will be monitored for any lift.

Solar Wind / Geomagnetic Activity: Solar winds have been indicative of a weak transient feature passing Earth, perhaps due to a glance from a CME, potentially coupled with the arrival of a weak enhancement from CH54/-. The CME arrival would have been before this 24 hour period, at around 18/2000 UTC, with ongoing weak magnetic cloud influence through this period indicated by a clear rotation in the field from 19/0400 UTC. This then continued through the 24 hours of this observation period. Solar winds speeds remained at background, around 300-350km/s, with density at or below average, but with a recent rising trend to above average at around 10-15ppcc. The total IMF, Bt, was Moderate at 10-15nT, with the Bz exhibiting a clear rotation through the period from around -6nT to +15nT. The phi angle was mainly negative (towards the Sun), but switched to positive (away from the Sun) at around 20/1100UTC. Geomagnetic activity remained Quiet.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background. High energy electron flux (greater than 2 MeV), as observed by GOES16, was at Background. The associated 24-hour fluence was below Active (1e8 integrated pfu). Observed fluence at 20/0000 UTC was 1.11e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with occasional C-flares and an ongoing likelihood of isolated M-flares. The most likely source is either AR3163 in the southwest, or AR3169 and AR3171 in the northeast. These also bring a very slight chance of X-class flares.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs, however a weak CME from the 18th has the small chance for a glancing interaction as it passes ahead of the Earth on day 3 (22nd). Onset of fast winds, due to the arrival of the HSS of CH55/- are expected day 1-2 (20th-21st), before only easing slightly through the following days (22nd-23rd). However

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confidence is low with strength and timing of any enhancement. Quiet geomagnetic activity at first, is expected to become Unsettled to Active later day 1 or day 2 (20th, 21st) with a chance of isolated G1/Minor Storm intervals. This chance decreases Day 3 and 4 (22nd and 23rd) with Quiet to Unsettled conditions following, and a chance of further Active intervals.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, although there is slight chance of this rising towards, perhaps reaching the S1 Minor Storm level given any notable flares. High energy (greater than 2 MeV) electron flux is expected to be at background at first, but perhaps rising to Moderate, or potentially reaching High by day 4 (23rd) depending on the strength of any fast wind enhancement. The associated 24-hour fluence is expected to persist below the Active (1e8 integrated pfu) threshold, perhaps rising later in the period.

Figure 1a. Solar Wind over the last three days, clear rotation in field visible. (Data spikes due to low density observations on DSCOVR)

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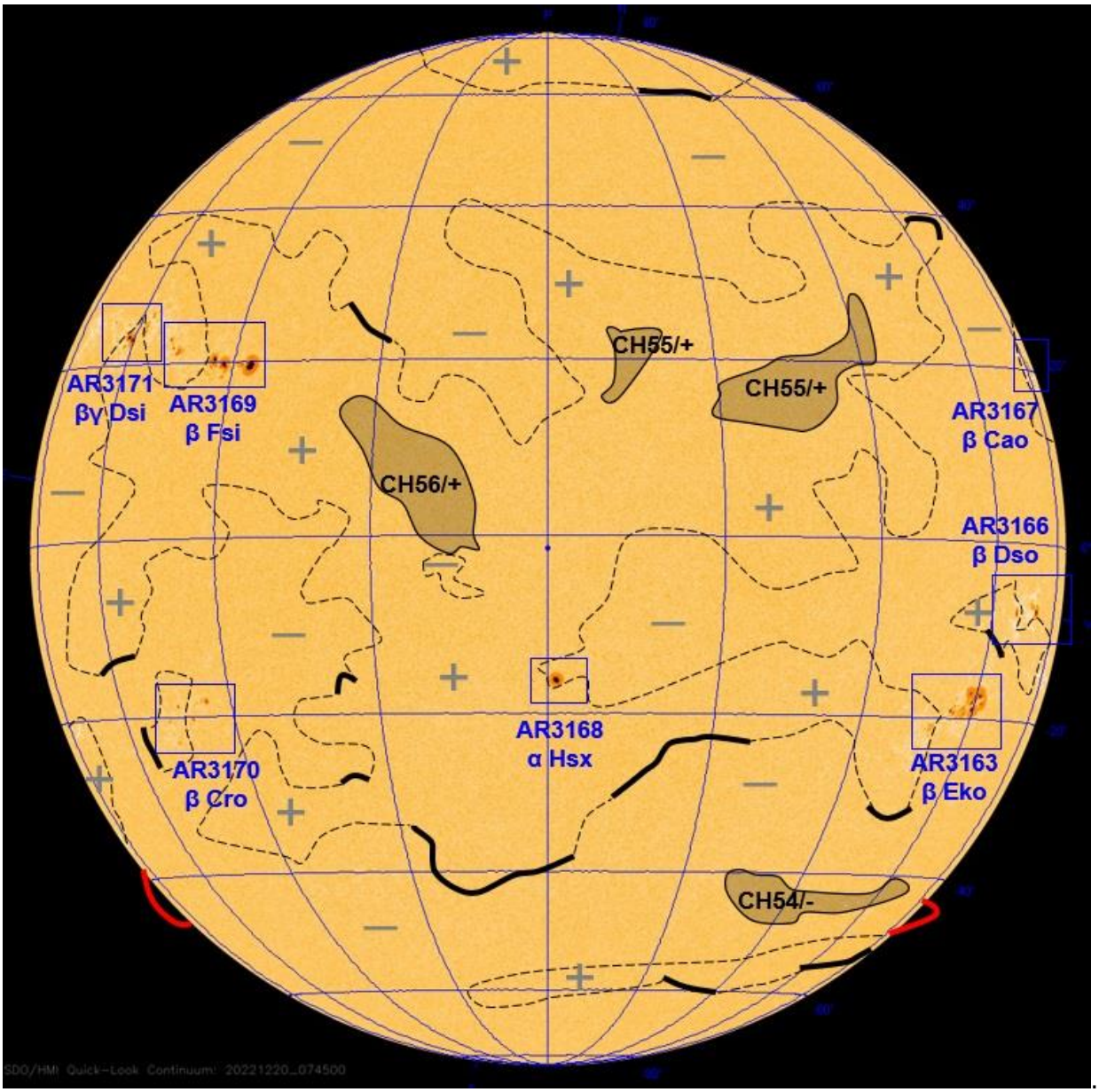
Figure 1b. Solar Analysis Valid 20/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs, however a weak CME from the 18th has a small chance for a glancing interaction as it passes ahead of the Earth on day 3 (22nd).

Solar winds are forecast to become elevated through day 1 and 2 (20th and 21st) due to the arrival of the fast wind from the onset of the HSS (high speed stream) of CH55/-. This is in agreement with MOSWOC Enlil and the 27-day persistence model, although CH55 is slightly more advanced westwards on this rotation. Confidence remains low on the strength and timing of this onset, however, due to a lack of notable enhancement occurring on STEREO A PLASTIC and MAG data. Ongoing fast winds are then expected, only easing slightly later day 3 and day 4 (22nd and 23rd), with the next HSS expected to arrive from CH56/- beyond this period, on day 5 (24th).

Quiet geomagnetic activity at first, expected to become Unsettled to Active later day 1 or day 2 (20th, 21st) with a chance of isolated G1/Minor Storm intervals. This chance decreases Day 3 and 4 (22nd and 23rd) with Quiet to Unsettled conditions following and a chance of further Active intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	30	40	20	5
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/1555	Partial	AR3162	SW	455 km/s	22nd Dec	Low Confidence

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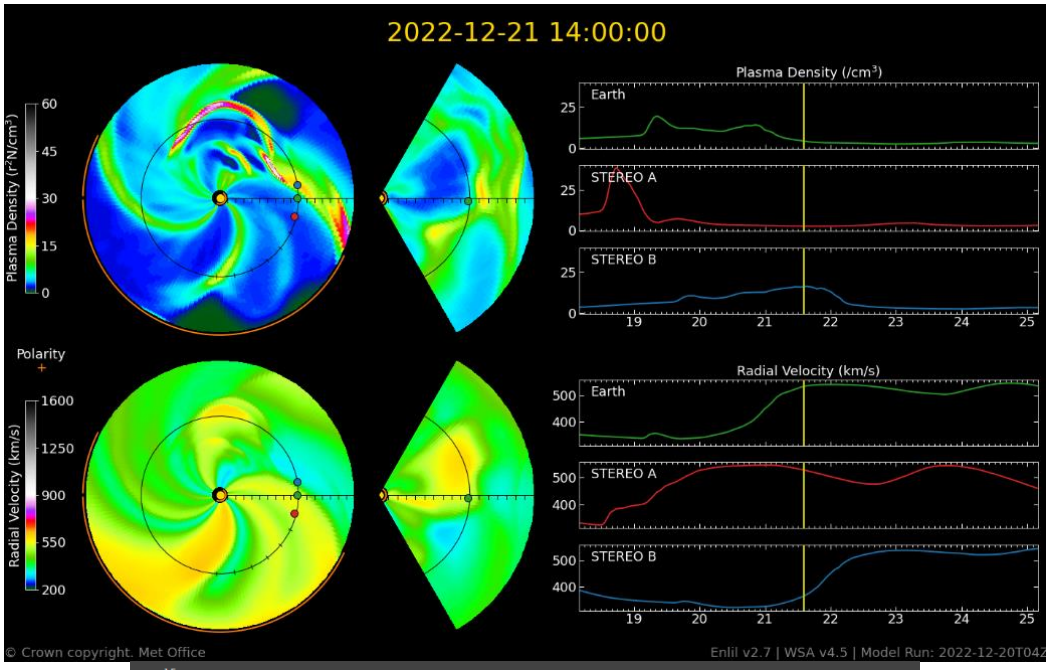
Figure 2a: Enlil and Ensemble Showing enhancement late 20th/21st from CH. Weak potential glance visible in one ensemble member on 22nd.



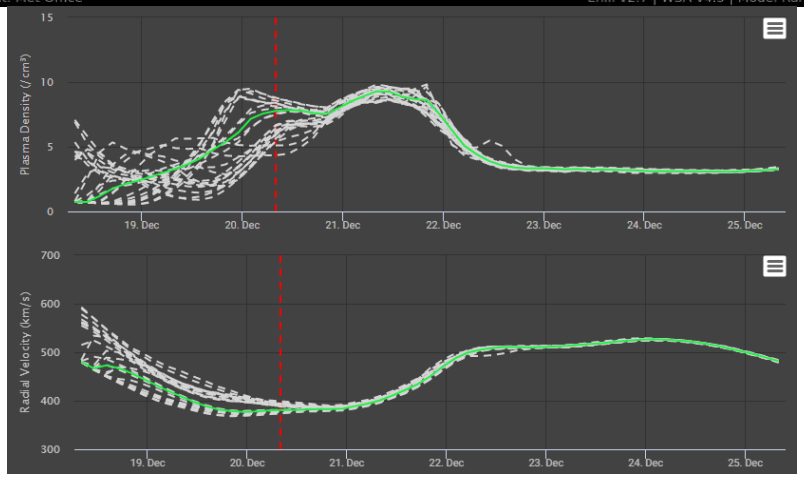
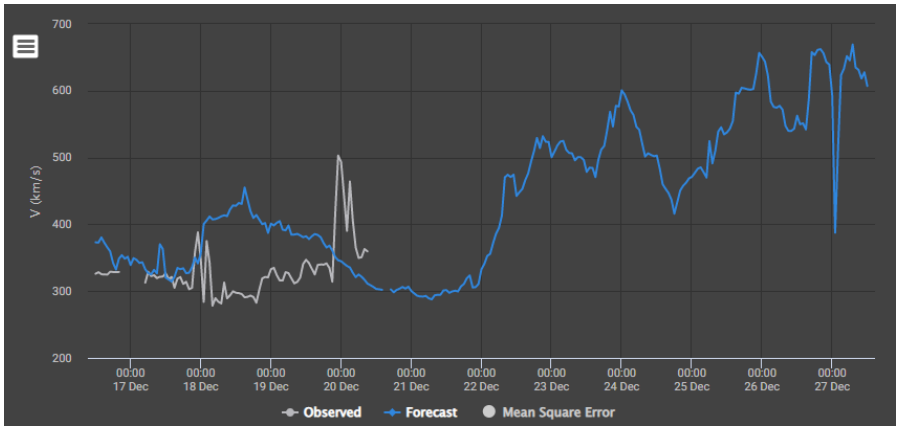


Figure 2b: MOSWOC 27-day persistence Model Shows enhancement later on the 21st or into the 22nd.



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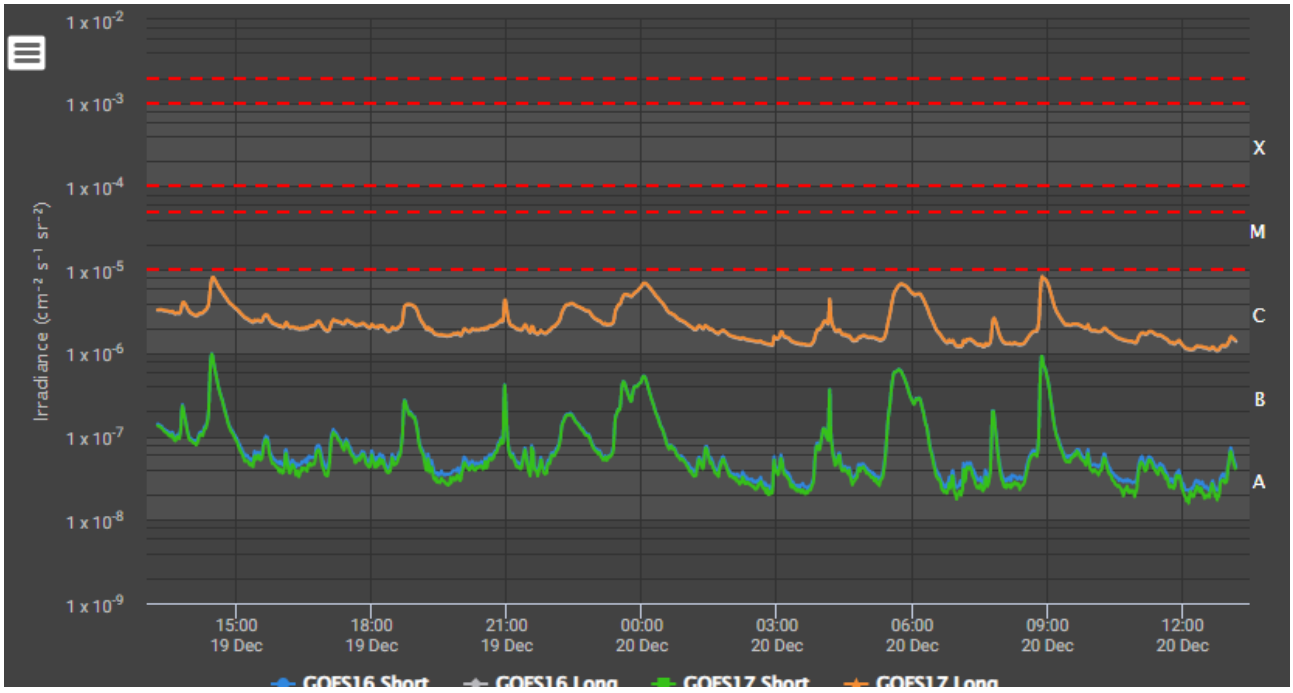
Radio Blackouts - X-Ray Flares:

There are seven sunspot regions on the visible disc with activity forecast to be Low to Moderate, with occasional C-flares and a chance of M-flares. There is a very slight chance of X-class flares.

AR3169 Fsi/Beta is currently the most active region on the disc, as an elongated group consisting of a number of mature but relatively small spots. This is followed by another relatively complex, but smaller region AR3171 Dsi/Beta-gamma, which due to a slightly less stable magnetic configuration also has the potential for notable flares. The largest region on the disc is AR3163 Eko/Beta. This is a mature spot that had been weakening in the last 24 hours, but has subsequently seen growth around its leader, with a nearby reverse polarity umbra and penumbra also developing in its vicinity adding to the potential complexity of the region. This is now approaching the southwest limb however. The other regions are generally smaller and simpler, however far-side products, such as helioseismic maps, suggest further regions are likely to rotate onto the disc though the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	50	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16/17 X-ray Flux



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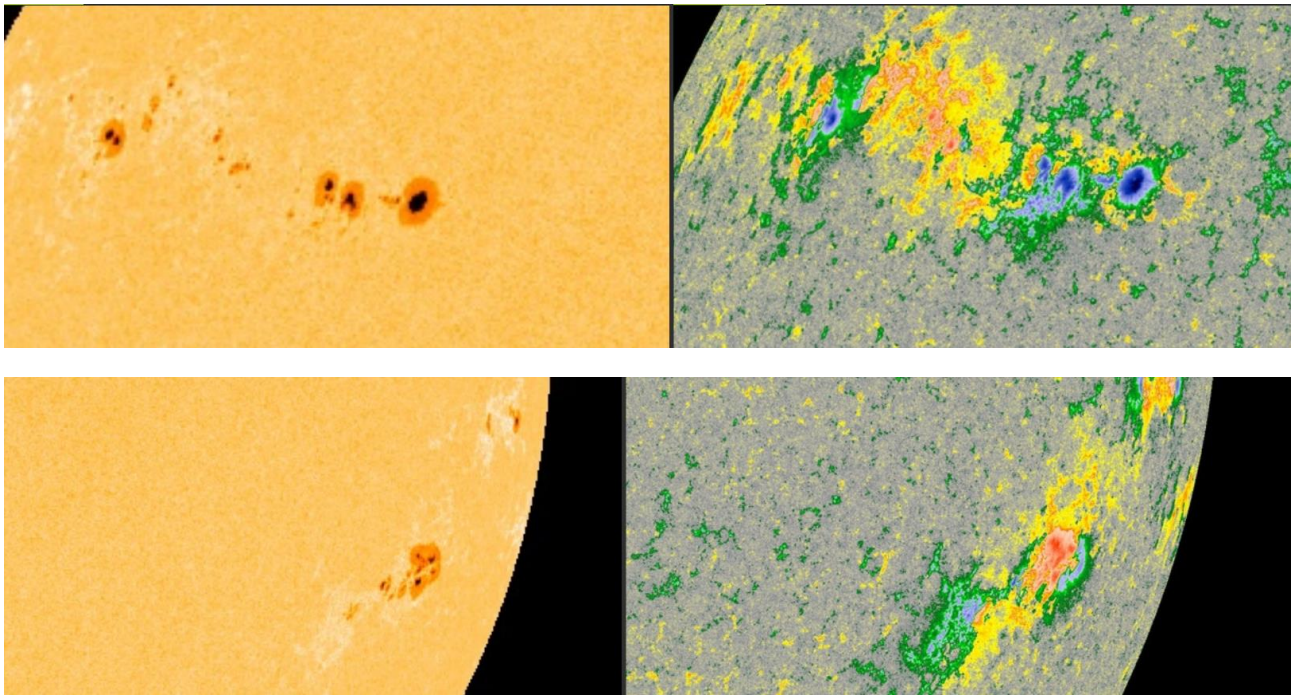
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is expected to remain at background. There is a slight chance of an enhancement however, with a number of notable sunspots on the disc. This giving a very slight chance of reaching the S1 Minor Radiation storm level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO hmi intensitygram (left) and magnetogram (right) of NE (top) and SW (bottom)



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High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2 MeV) electron flux as observed by GOES-16 is currently at background levels. Fast solar wind arrival on day 1 or day 2 has the potential to result in increased counts later in the period, most likely rising to Moderate, with a chance of a diurnal peak of High on days 3 and 4 (22nd and 23rd).
The associated 24 hour electron fluence is forecast to remain below the active threshold, as indicated by REFM, which is currently giving good guidance. There is a slight chance of fluence rising later in the period, however this is low confidence at this stage.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 Electron Flux and Fluence with REFM

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